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NANTICOKE WATER MOVEMENTS 1978

September 1979



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Ministry
of the
Environment

The Honourable
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Minister

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NANTICOKE WATER MOVEMENTS 1978

Summary

Current meters were operated from July 25 to August 18, 1978 at mid-depth under the two bridges of the Stelco dock in the Nanticoke Region of Lake Erie. For approximately one third of the time, no water movements were observed under either bridge. This being a normal occurrence in the coastal regions, it was not attributed to the presence of the Stelco dock. Under the outer bridge, the currents were bimodal along an east-west direction. Currents were relatively faster under the outer bridge as compared to those under the inner bridge. The arithmetic average current speed was 4.1 cm.s^{-1} under the outer bridge and 1.5 cm.s^{-1} under the inner bridge. The maximum current speeds were 26 and 11 cm.s^{-1} under the outer and inner bridges respectively. The mean water temperatures at the two locations indicate a thermal gradient from the shore to the lake or due to the vertical thermal structure.

THE NANTICOKE WATER MOVEMENTS 1978

INTRODUCTION

As part of the ongoing interdisciplinary (biological, chemical and physical) study by the Nanticoke Environmental Committee (NEC, 1973 and 1978), water movements under the bridges of the Stelco dock were investigated. The purpose of this investigation was to assess the water movements under the two bridges of the dock. Uninterrupted flow of water under the bridges across the dock is considered essential for the free movement of fish and sediment so as not to disrupt the natural aquatic life and sediment transport.

Two Plessy M021 self recording and submersible type instruments were deployed to record current speed and direction as well as water temperature. The instruments operated at mid-depth under the nearshore and offshore bridges of Stelco dock (see Figure 1). The instruments were calibrated prior to installation on July 25, 1978, followed by a post-mooring check after removal on August 18, 1978 (see Appendix 1 for details).

The two data sets were numerically smoothed (see Appendix 1) and then subjected to statistical analyses to determine the water movement characteristics. Spectral analyses were also performed on the two data sets to identify the physical processes responsible for the water movements.

DISCUSSION

Table 1 presents the statistical summary of currents at locations 0218 and 0219 from July 25 to August 18, 1978. At the two sites, the resultant speeds (vector average) were 0.4 and 0.9 cm.s^{-1} , the arithmetic mean current speeds were 4.1 and 1.5 cm.s^{-1} and the maximum speeds recorded during the study period were 26 and 11 cm.s^{-1} . The currents were negligible for 38% of the recorded time under the inner bridge and 29% of the study period under the outer bridge. Thus, there was no water movement under the bridges for approximately one third of the study period. It is not known if such periods of stagnation under the bridges persist during other months and seasons. At other lake locations in the Nanticoke study area, the percentage of negligible currents have been generally similar and varied from 15 to 74 (NEC, 1973; Kohli, 1976). Therefore, the periods of no movement may be considered normal for the coastal areas and not due to the bridge and dock construction.

At the outer station (0218), the resultant current was very small (0.4 cm.s^{-1}). This may be attributed to the bimodal distribution (see Figure 2) of currents along the east-west directions. The currents at the outer bridge location may be compared with those on either side of the bridge as measured during July and August 1976 (Kohli, 1978). The resultant currents during 1976 varied from 0.7 to 1.3 cm.s^{-1} , the arithmetic mean speed ranged from 2.0 to 3.5 cm.s^{-1} while the maximum speed recorded was 18 cm.s^{-1} . These results compare well with the outer bridge current statistics except that resultant current speed in 1978 was 0.4 cm.s^{-1} .

Figure 3 presents the current distribution rose at the nearshore bridge location. Here, the currents were generally slower than those at the outer station. The slower currents may be due to the proximity of the shore.

Figures 4 to 7 show the plots of variance density spectra of the north-south or east-west current components at both locations. No significant periodicities were observed. Consequently there were no lakewide, baywide or local shore effects on current periodicities under either bridge. Therefore currents under the bridge may be wind generated and/or due to water level fluctuations across the Stelco dock.

The one-dimensional frequency of occurrence of water temperature at both locations is presented in Table 2. From July 25 to August 18, 1978, the mean water temperature at the inner bridge location (0219) was 20.8°C with a standard deviation of 1.9°C. The mean water temperature at the outer bridge location (0218) was 19.3°C with a standard deviation of 2.0°C. The water temperatures at two locations were statistically compared by "students" t test. This test resulted in:

$$t_{572} = 10.77 > t_{0.01, 572} = 3.29$$

Therefore it may be concluded that the two locations have different water temperatures. As the instruments were operated at mid depth in 4.0 m and 11.5 m of water, the temperature gradient may be due to the vertical thermal structure or the horizontal temperature gradient from the shore to the lake. Water temperatures between 20 and 22°C occurred for 44% (offshore bridge) and 60% (nearshore bridge) of the study period.

Conclusions

No water movements were observed for one third of the study period under the Stelco bridge. However, this was considered normal for the coastal region and was not attributed to the presence of the Stelco dock. Bimodal currents along an east-west direction were observed under the outer bridge where the currents were generally faster than those under the inner bridge. The arithmetic average speed at the outer location was 4.1 cm.s^{-1} while it was 1.5 cm.s^{-1} at the inner site. The maximum recorded speeds were 26 and 11 cm.s^{-1} at the outer and inner bridges respectively. The mean water temperature was 19.3°C and 20.8°C respectively at the offshore and nearshore locations; suggesting the presence of a thermal gradient from the shore toward the lake or due to the vertical thermal structure.

The spectral analyses of the currents showed no significant periodicities. The currents under the bridges were attributed to wind and/or the water level fluctuations across the Stelco dock.

REFERENCES

1. Kohli, B. 1976. Water Movements in the Nanticoke Region of Lake Erie 1974. Ontario Ministry of the Environment, 135 St. Clair Ave. W., Toronto, Ontario, 26p.
2. Kohli, B. 1978. Water Movements in the Nanticoke Region of Lake Erie 1976. Ontario Ministry of the Environment, 135 St. Clair Ave. West, Toronto, Ontario, 30p.
3. NEC (Nanticoke Environmental Committee) 1973. The Aquatic Ecosystem of Longpoint Bay in the Vicinity of Nanticoke, Vol.3, Water Movements. 108p.
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TABLE 1: Statistical Summary of Current Meter Operations,
Under Stelco Dock Bridges, Nanticoke, Lake Erie
July 25 to August 18, 1978.

	L O C A T I O N	
	0218 Offshore	0219 Nearshore
Resultant direction (0° as North)	347	339
Resultant Speed (cm.s ⁻¹)	0.38	0.88
Average Speed (cm.s ⁻¹)	4.13	1.47
Maximum Speed (cm.s ⁻¹)	26	11
Persistence Factor	0.09	0.60
Percentage of negligible* speed (% of recording period)	29	38
Total number of readings	3441	3444
Interval of readings (mins.)	10	10

* < 0.30 cm.s⁻¹

TABLE 2: Temperature Frequency, Under Stelco Dock Bridges,
Nanticoke, Lake Erie, July 25, to August 18,
1978. (Percentage of Occurrence)

Temperature Range °C	L O C A T I O N	
	0218 Offshore	0219 Nearshore
13.00 - 13.99	0.53	
14.00 - 14.99	4.21	
15.00 - 15.99	3.86	1.93
16.00 - 16.99	4.91	5.26
17.00 - 17.99	13.33	7.37
18.00 - 18.99	18.25	1.40
19.00 - 19.99	7.37	5.44
20.00 - 20.99	24.56	22.81
21.00 - 21.99	19.82	37.02
22.00 - 22.99	3.16	8.25
23.00 - 23.99		8.95
24.00 - 24.99		1.58
Total	100.00	100.00
Mean °C	19.26	20.76
Std. Dev. °C	2.04	1.92
Minimum °C	13.89	15.02
Maximum °C	22.94	24.35
Series Length (h)	573	574

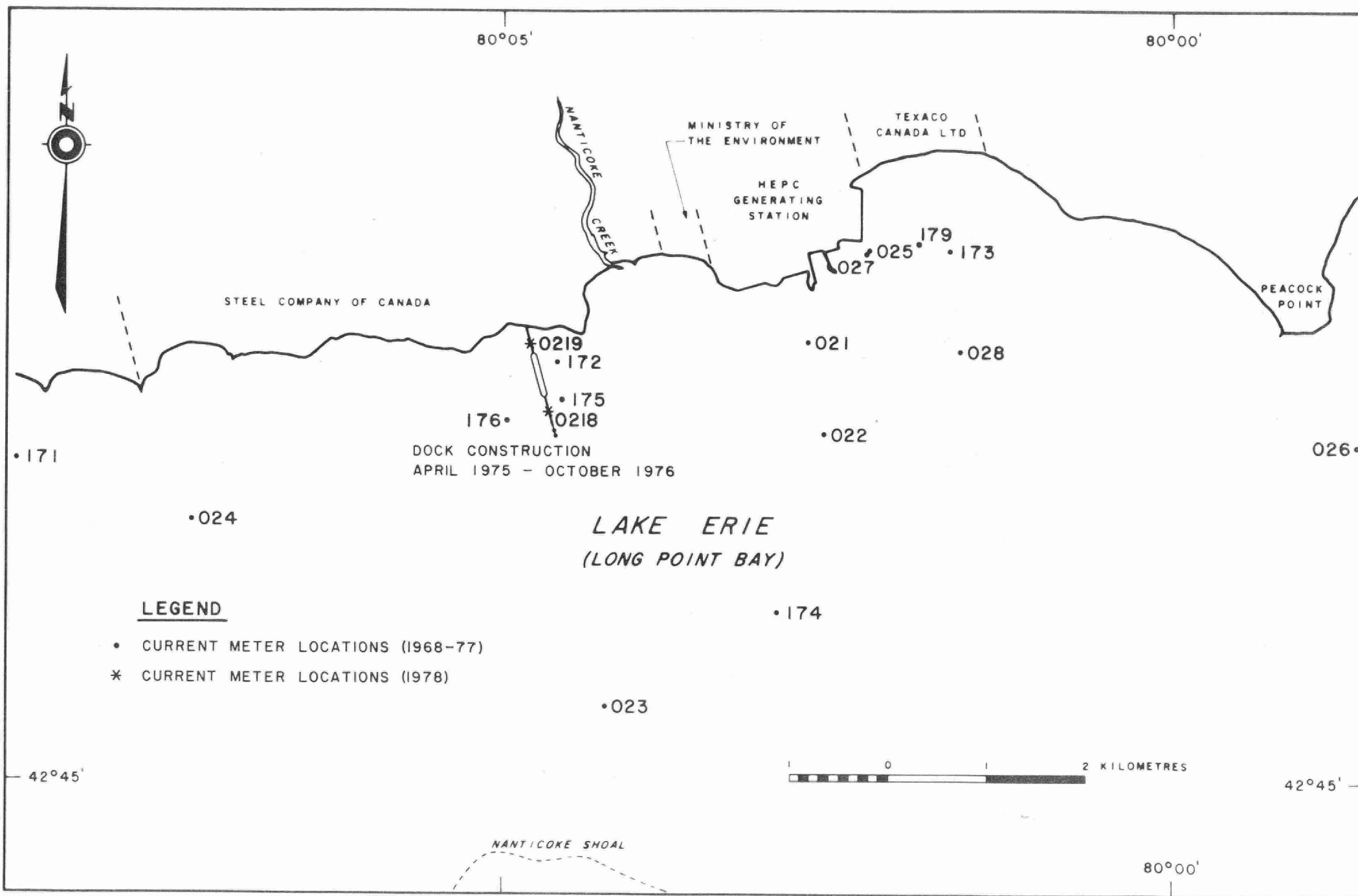


FIGURE 1 - STUDY LOCATIONS FOR PREVIOUS YEARS (1968-78) OFFSHORE OF NANTICOKE, LAKE ERIE

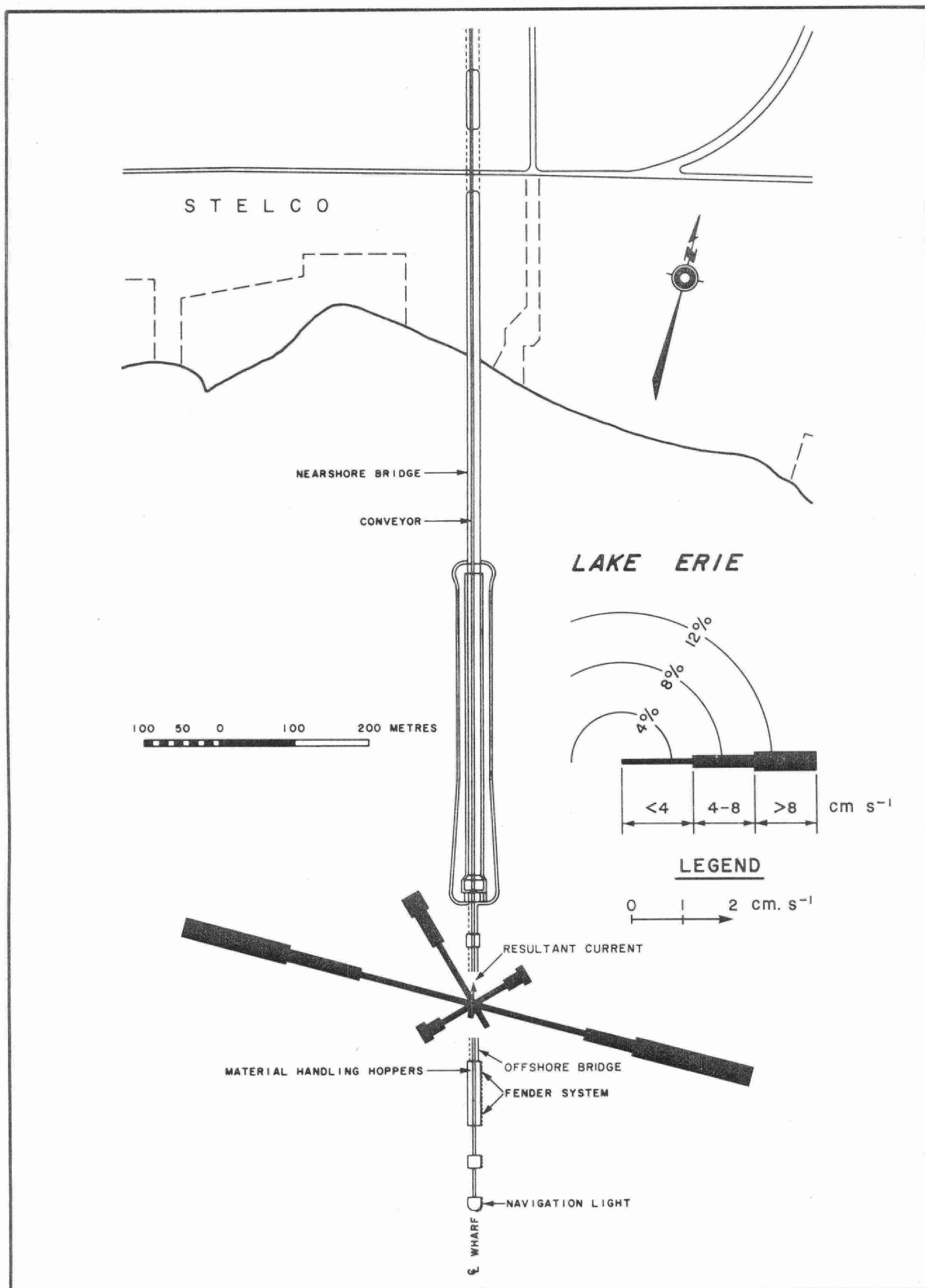


FIGURE 2 - CURRENT FREQUENCY ROSE, OUTER BRIDGE (STELCO DOCK)
25 JULY - 18 AUG. 1978.

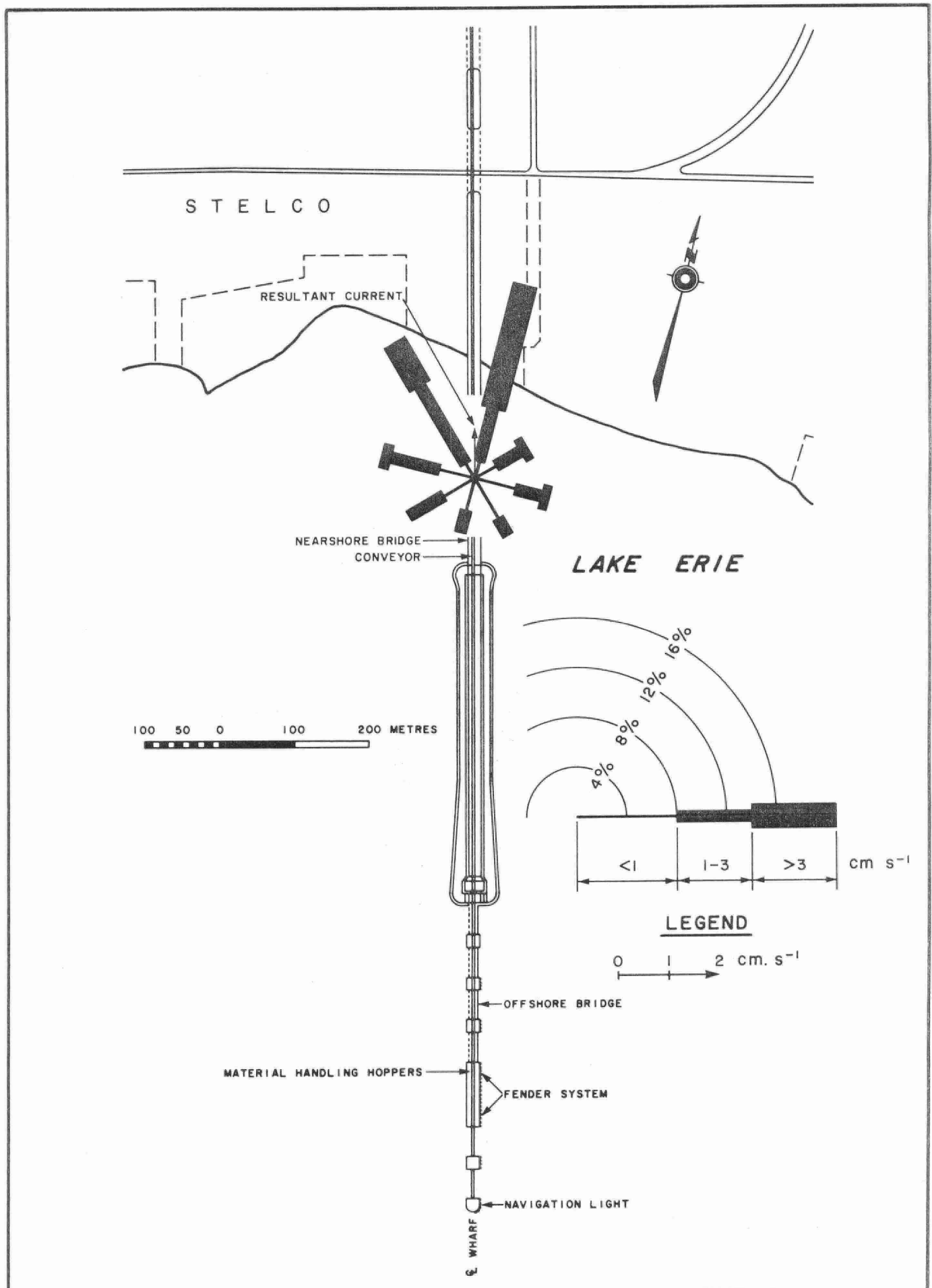


FIGURE 3 - CURRENT FREQUENCY ROSE, INNER BRIDGE (STELCO DOCK)
25 JULY - 18 AUG. 1978.

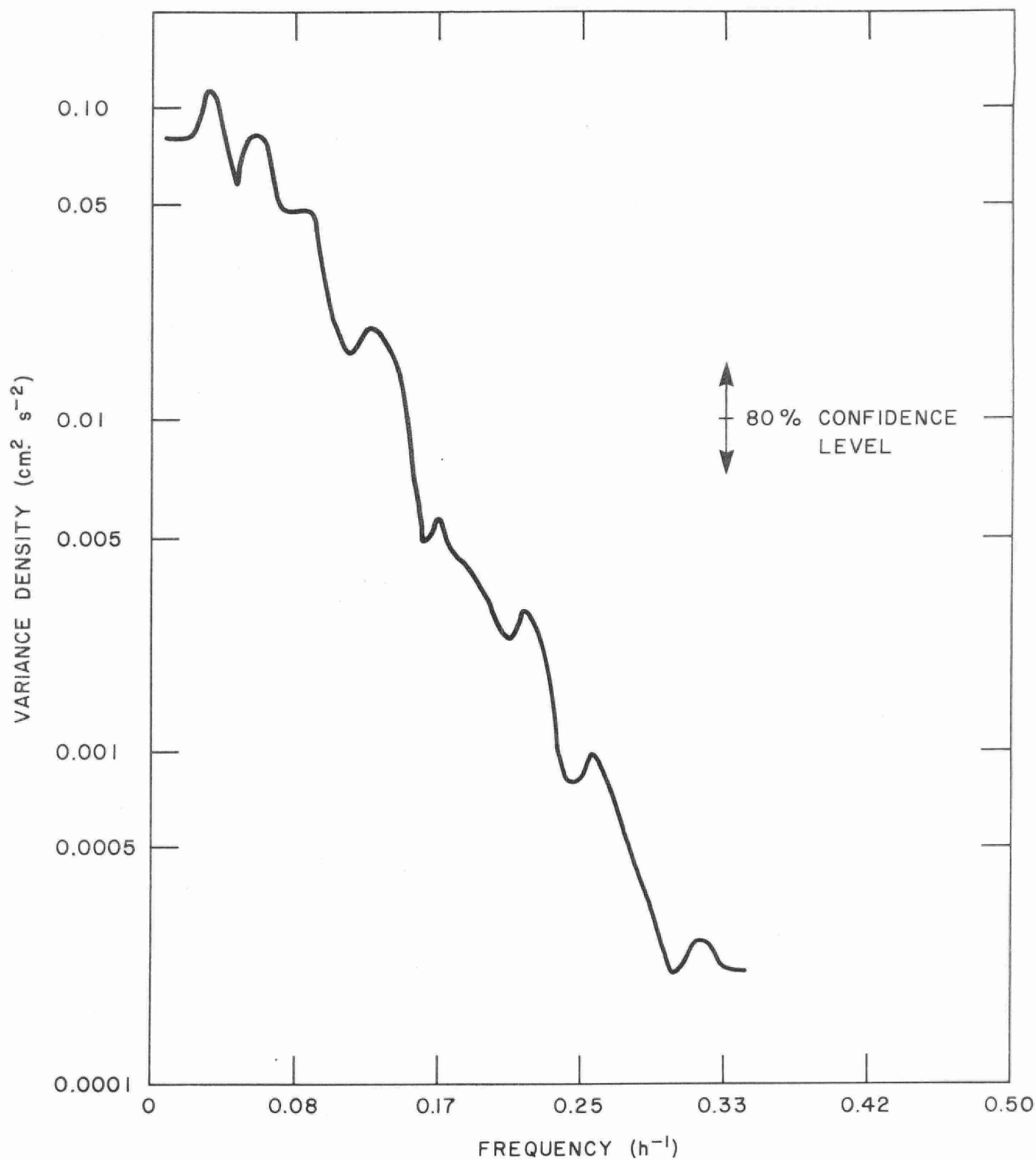


FIGURE 4 - VARIANCE DENSITY SPECTRA FOR N-S CURRENTS, LOCATION 0218 25 JULY - 18 AUG. 1978, NANTICOKE, LAKE ERIE.

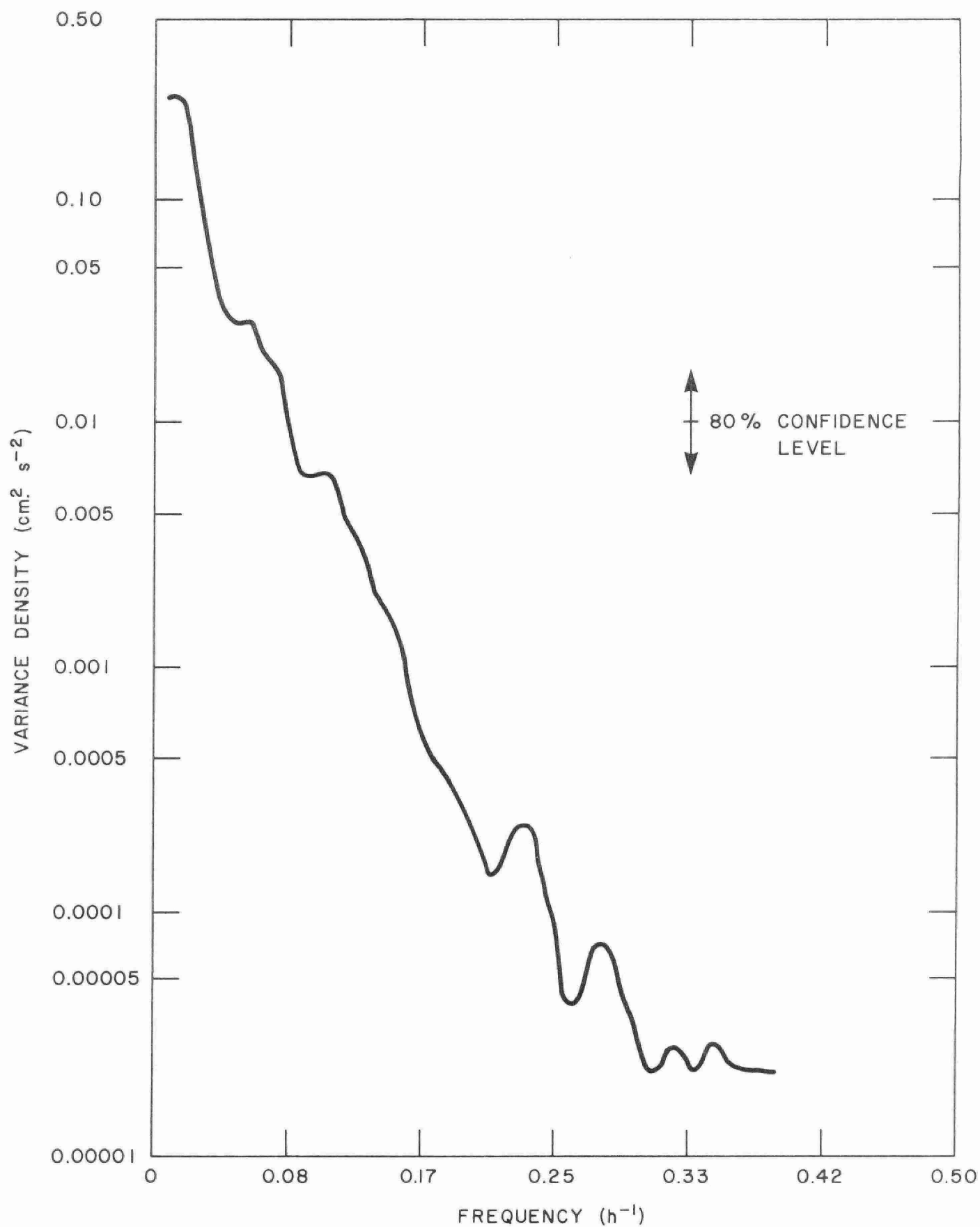


FIGURE 5 - VARIANCE DENSITY SPECTRA FOR E-W CURRENTS, LOCATION 0218 25 JULY - 18 AUG. 1978, NANTICOKE, LAKE ERIE.

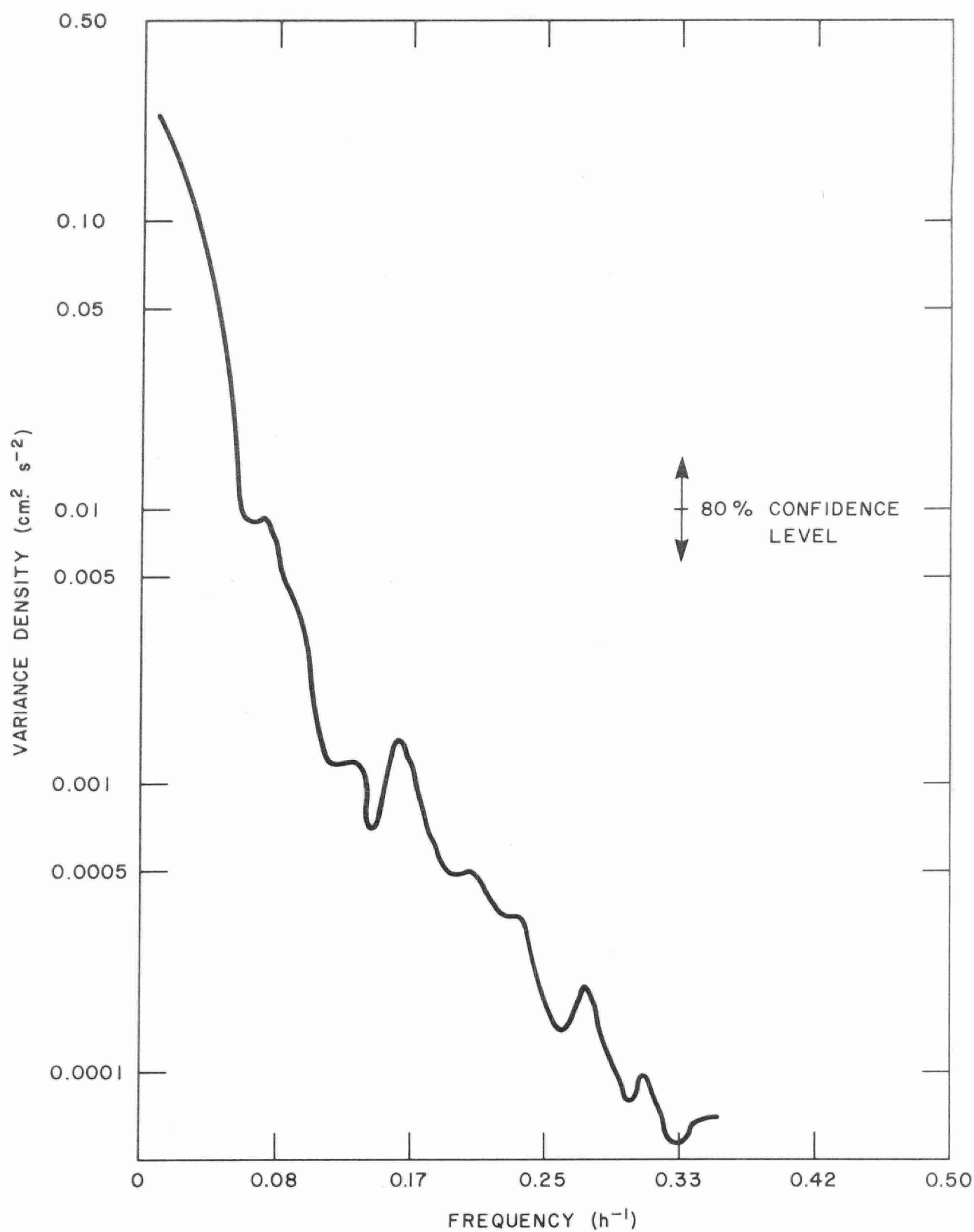


FIGURE 6 - VARIANCE DENSITY SPECTRA FOR N-S CURRENTS, LOCATION 0219 25 JULY - 18 AUG. 1978, NANTICOKE, LAKE ERIE.

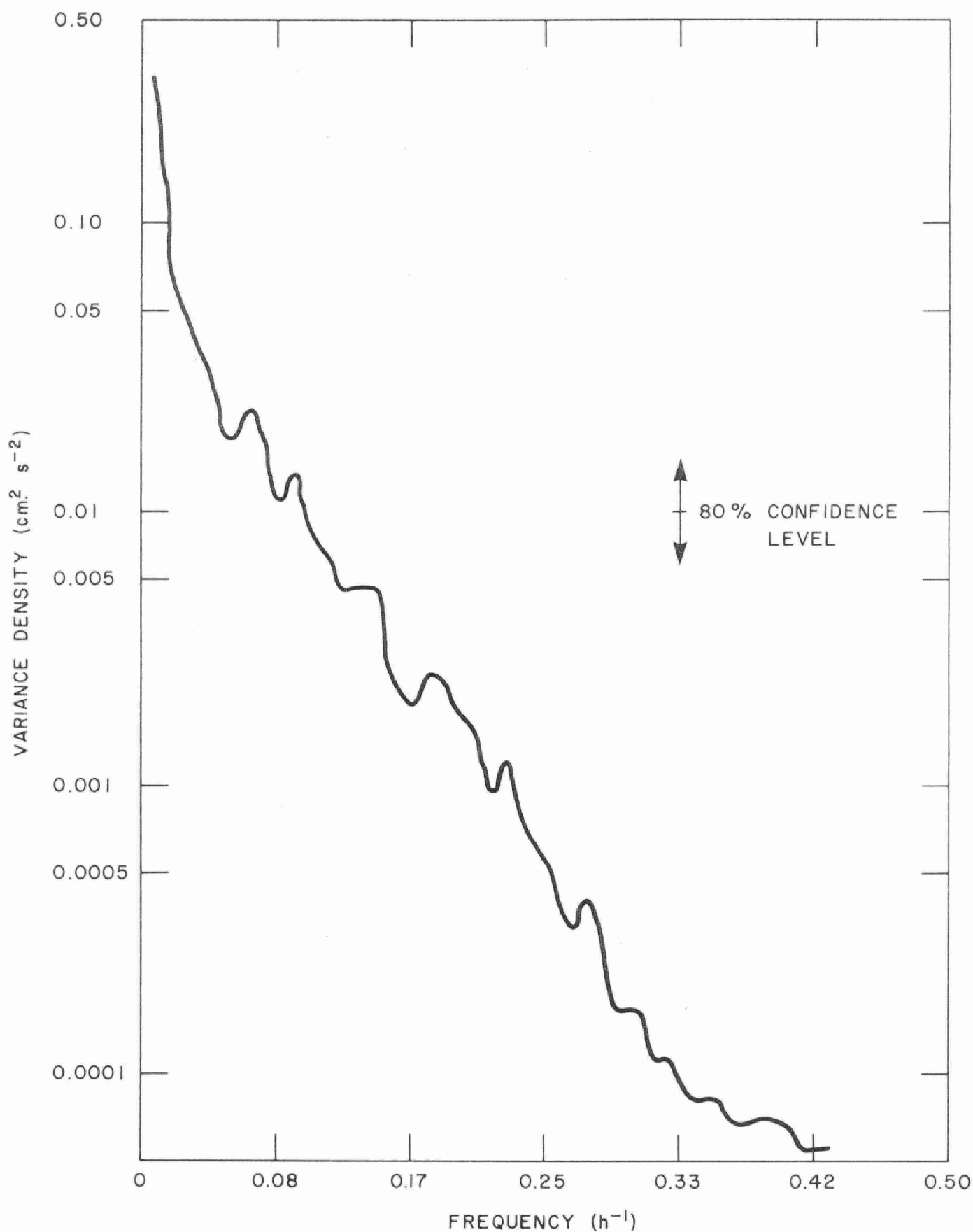


FIGURE 7 - VARIANCE DENSITY SPECTRA FOR E-W CURRENTS,
LOCATION 0219 25 JULY - 18 AUG. 1978, NANTICOKE,
LAKE ERIE.

APPENDIX 1

INSTRUMENT AND DATA ANALYSIS 1978

INSTRUMENT OPERATION

Two Plessy submersible self recording instruments were operated, one each under the inner and outer bridges of the Stelco dock (see Figure 1) from July 25 to August 18, 1978. Both instruments were laboratory calibrated prior to mooring and also checked after the study. The instruments were installed at mid-depth, 5.8 m from bottom in 11.5 m of water for the outer bridge location and 2.0 m from bottom in 4.0 m of water for the inner bridge. Water temperature, current direction and speed were recorded every 10 minutes. Current speed recorded was the integrated value over the 10 minute interval while the water temperature and current direction recorded were the instantaneous values. Although the threshold speed of Plessy instruments is 3.0 cm.s^{-1} , speeds lower than the threshold speed can be recorded because of the integration over the time interval.

Data Analysis

The data were numerically smoothed or prewhitened after Blackman and Tukey (1959; p.29, 39, 74) using binomial coefficients after Panofsky and Brier (1968; p.150). The smoothed data were subjected to statistical analysis to compute the two-dimensional frequency of occurrence of current speed and direction. These frequency tables are presented in Table 1.01 and 1.02.

Current velocities were resolved along the north-south and east-west directions and then the hourly averages along the two major directions were contributed. The two series of hourly current speed were subjected to time series (spectral) analysis by the standard numerical techniques (Kohli, 1978). The Fourier coefficient were smoothed by the Hanning (Blackman and Tukey, 1959; p.34 and 171). The spectral analysis identifies the variance distribution with respect to time (see Figure 4 to 7) and therefore provides information on the physical processes responsible for the generation of currents in the study area.

REFERENCES

1. Blackman, R.B., and J.W. Tukey, 1959. The Measurement of Power Spectra. Dover Publications, Inc. New York, 198p.
2. Kohli, B. 1978. Physical Aspects of Toronto Harbour. 1972-75. Ontario Ministry of the Environment, 135 St. Clair Ave. West., Toronto, Ontario. 50p.
3. Panofsky, H. A. and G. W. Brier, 1968. Some Applications of Statistics to Meteorology. The Pennsylvania State University, University Park, Pennsylvania.

TABLE 1.01

LOCATION CODE : 0218
 AREA : NANTICOKE
 LAKE : ERIE

PERIOD : AUG 78
 LATITUDE : 80 01 57 W
 LONGITUDE : 42 47 00 N

FREQUENCY TABLE

DIRECTION (ZERO DEGREE AS NORTH)										
SPEED (CM/S)	337.50-	22.50-	67.50-	112.50-	157.50-	202.50-	247.50-	292.50-		
	22.49	67.49	112.49	157.49	202.49	247.49	292.49	337.49	ROW SUMS	
0.0 --	0.30	0.93	0.99	5.20	4.97	2.73	3.60	7.50	2.94	28.86
0.31 --	1.99	1.08	1.71	5.70	1.74	1.10	2.53	5.87	2.47	22.20
2.00 --	3.99	0.76	1.10	3.25	0.41	0.26	0.78	3.78	2.73	13.08
4.00 --	5.99	0.12	0.70	2.35	0.15	0.03	0.70	4.30	2.24	10.58
6.00 --	7.99	0.03	0.29	1.45	0.09	0.03	0.29	1.86	1.08	5.11
8.00 --	9.99	0.03	0.20	1.02	0.09	0.03	0.09	1.51	0.81	3.78
10.00 --	26.99	0.0	0.35	8.34	0.0	0.0	0.29	6.89	0.52	16.39
COLUMN SUMS	2.94	5.35	27.32	7.44	4.18	8.28	31.71	12.79	100.00	

RESULTANT CURRENT IS 0.38 CM/S AT 347 DEG FROM NORTH
 MEAN CURRENT IS 4.13 CM/S
 MAXIMUM CURRENT IS 26.21 CM/S
 MINIMUM CURRENT IS 0.0 CM/S

TOTAL NO. READINGS 3441
 PERSISTENCE IS 0.09
 READINGS TAKEN EVERY 10 MIN

METER OPERATIONS

METER OPERATED AT 5.8 M FROM BOTTOM IN 11.5 M OF WATER

STARTED AT 13.57 HRS. ON 25 TH DAY OF 7 TH MONTH 1978
 ENDED AT 11.16 HRS. ON 18 TH DAY OF 8 TH MONTH 1978

TABLE 1.02

LOCATION CODE : 0219
 AREA : NANTICOKE
 LAKE : ERIE

PERIOD : AUG 78
 LATITUDE : 80 01 57 W
 LONGITUDE : 42 47 00 N

FREQUENCY TABLE

DIRECTION (ZERO DEGREE AS NORTH)										
SPEED (CM/S)	337.50-	22.50-	67.50-	112.50-	157.50-	202.50-	247.50-	292.50-		
	22.49	67.49	112.49	157.49	202.49	247.49	292.49	337.49	ROW SUMS	
0.0 --	0.30	2.18	3.63	10.57	8.19	6.45	3.57	2.32	1.22	38.12
0.31 --	0.99	1.42	2.26	3.19	3.77	2.73	2.99	2.87	1.25	20.50
1.00 --	1.99	2.21	1.39	1.68	1.19	1.60	2.56	2.15	2.70	15.48
2.00 --	2.99	1.97	0.81	0.49	0.15	0.32	0.46	1.77	4.41	10.39
3.00 --	3.99	1.77	0.20	0.26	0.06	0.03	0.0	0.49	1.51	4.33
4.00 --	4.99	2.24	0.06	0.06	0.03	0.0	0.0	0.0	0.93	3.31
5.00 --	11.99	6.13	0.09	0.23	0.0	0.0	0.0	0.06	1.36	7.87
COLUMN SUMS	17.92	8.45	16.49	13.39	11.12	9.58	9.67	13.39	100.00	

RESULTANT CURRENT IS	0.88 CM/S AT	339 DEG FROM NORTH	TOTAL NO. READINGS	3444
MEAN CURRENT IS	1.47 CM/S		PERSISTENCE IS	0.60
MAXIMUM CURRENT IS	11.35 CM/S		READINGS TAKEN EVERY	10 MIN
MINIMUM CURRENT IS	0.0 CM/S			

METER OPERATIONS

METER OPERATED AT 2.0 M FROM BOTTOM IN 4.0 M OF WATER

STARTED AT 12.37 HRS. ON 25 TH DAY OF 7 TH MONTH 1978
 ENDED AT 10.26 HRS. ON 18 TH DAY OF 8 TH MONTH 1978



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